

**ANALYTICAL METHOD FOR TURBIDITY MEASUREMENT
GLI METHOD 2**

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DRAFT

Analytical Method for Turbidity Measurement

GLI Method 2

1. Scope and Application

- 1.1 This method is applicable to drinking water samples in the range of turbidity from 0 to 40 nephelometric units (NTU). Higher values may be obtained with dilution of the sample. A method detection limit of 0.100 NTUs is recommended for this procedure.

NOTE: NTUs are considered comparable to the previously reported Formazin Turbidity Units (FTU).

2. Summary of Method

- 2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of the scattered light, the higher the turbidity. Readings, in NTUs, are made in a nephelometer designed according to specifications outlined in "APPARATUS." A standard suspension of Formazin, prepared under closely defined conditions, is used to calibrate the instrument.
- 2.1.1 Formazin polymer is used as the turbidity reference suspension for water because it is more reproducible than other types of standards previously used for turbidity standards.

3. Sample Handling and Preservation

- 3.1 Collect each sample in a soft or hard plastic, or soft or hard glass container. Immediately refrigerate or ice the sample to 4°C and analyze within 48 hours.

4. Conditions Affecting Turbidity Reading

- 4.1 The presence of floating debris and coarse sediments, which settle out rapidly, will give low readings. Finely divided air bubbles will affect the results in a positive manner.
- 4.2 The presence of color, that is the color of water which is due to dissolved substances which absorb light, will cause turbidities to be low, although this effect is generally not significant.

5. Apparatus

- 5.1 The turbidimeter shall consist of a nephelometer with two light sources for illuminating the sample and two detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. The turbidimeter shall accomplish two measurement phases every 0.5 seconds (see Figure 1).

In the first phase, Light Source #1 shall pulse a beam of light directly into Photodetector #2. Simultaneously, Photodetector #1 shall measure the light scattered at a 90 degree angle. Diffused light measured by Photodetector #2 shall be called a reference signal while scattered light measured by Photodetector #1 shall be called an active signal.

In the second phase, Light Source #2 shall pulse a beam of light directly into Photodetector #1. Simultaneously, Photodetector #2 shall measure the light scattered at a 90 degree angle. This time, the diffused light measured by Photodetector #1 shall be called a reference signal and scattered light measured by Photodetector #2 shall be called an active signal.

The two-phase measurement shall provide four independent measurements from the two light sources; two reference signals and two active signals. A "ratiometric" algorithm will then be used to calculate the turbidity value from these four measurements.

The turbidimeter should be so designed that little stray light reaches the detector in the absence of turbidity and should be free from significant drift after a short warm-up period.

- 5.2** The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 units or less in waters having turbidities less than 1 unit. The instrument should measure from 0 to 40 units turbidity. Several ranges will be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.
- 5.3** The sample tubes to be used with the available instrument must be of clear, colorless optical glass. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. They must not be handled at all where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be handled.
- 5.4** Any apparatus may be used, provided that it complies with the following requirements:
 - 5.4.1** The wavelength of the incident radiation shall be 860 nm;
 - 5.4.2** The spectral bandwidth of the incident radiation shall be less than or equal to 60 nm;
 - 5.4.3** There shall be no divergence from parallelism of the incident radiation and any convergence shall not exceed 1.5 degrees;

5.4.4 There shall be two light sources and two detectors;

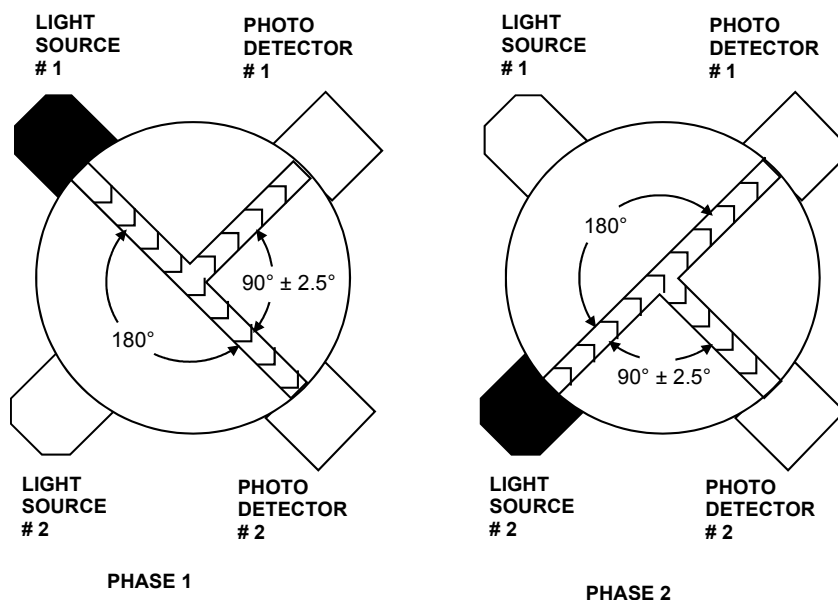


Figure 1

5.4.5 The measuring angle between the optical axis of the incident radiation and that of the diffused radiation for light pulsed through the sample by Light Source #1 shall be 90 ± 2.5 degrees;

5.4.6 The measuring angle between the optical axis of the incident radiation and that of the diffused radiation for light pulsed through the sample by Light Source #2 shall be 90 ± 2.5 degrees.

The narrow definition of the light source makes it unnecessary to specify sensitivity of the photodetector.

6. Reagents

6.1 Turbidity-free water: Pass distilled water through a membrane filter having precision-sized holes of $0.2 \mu\text{m}$; the usual membrane filter used for bacterial examinations is not satisfactory (Sec. 3.1, EPA-approved Standard Method 214A, 16th edition).

6.2 Stock formazin turbidity suspension:

Solution 1: Dissolve 1.00 g hydrazine sulfate, $(\text{NH}_2)_2\text{H}_2\text{SO}_4$, in distilled water and dilute to 100 mL in a volumetric flask.

Solution 2: Dissolve 10.00 g. hexamethylenetetramine in distilled water and dilute to 100 mL in a volumetric flask. In a 100 mL volumetric flask, mix 5.0 mL Solution 1 with 5.0 mL Solution 2. Allow to stand 24 hours at $24^\circ\text{C} \pm 2.5^\circ\text{C}$, then dilute to the mark and mix.

6.3 Standard formazin turbidity suspension: Dilute 10.00 mL stock turbidity suspension to 100 mL with turbidity-free water. The turbidity of this suspension is defined as 40 units. Dilute portions of the standard turbidity suspension with turbidity-free water as required.

7. Procedure

- 7.1** Turbidimeter calibration: The manufacturer's operating instructions should be followed. Measure standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales. At least one standard should be run in each instrument range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities. If a pre-calibrated scale is not supplied, then calibration curves should be prepared for each range of the instrument.
- 7.2** Turbidities less than 40 units: Shake the sample to thoroughly disperse the solids. Wait until air bubbles disappear. Then pour the sample into the turbidimeter tube. Read the turbidity directly from the instrument scale or from the appropriate calibration curve.
- 7.3** Turbidities exceeding 40 units: Dilute the sample with one or more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and the diluted sample showed a turbidity of 30 units, then the turbidity of the original sample was 180 units.

8. Calculations

8.1 Nephelometric turbidity units (NTU)

$$= \frac{A \times (B + C)}{C} \quad \text{where:} \quad \begin{array}{l} A = \text{NTU found in diluted sample} \\ B = \text{volume of dilution water, in mL} \\ C = \text{sample volume taken for dilution, in mL} \end{array}$$

8.2 Report results as follows:

NTU	Record to Nearest
0.0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 - 1000	50
> 1000	100

9. Precision and Accuracy

- 9.1** In a single laboratory, using surface waters filtered to minimum turbidity with 0.04 micron filters and dosed with formazin to levels of 0.47, 0.91, 5.6, 9.8, 39.3, 82.7 and 99.4 NTU. The \pm standard deviations were 0.007, 0.014, 0.1, 0.22, 0.45, 0.7 and 0.83 units respectively.

9.2 Accuracy of the Great Lakes Instruments Turbidity Method

The range of the mean percent recoveries of turbidity from 10 fortified drinking water samples, each analyzed in triplicate by the Great Lakes Instruments Turbidity Method, was as follows:

Turbidity Added to Sample	Range of Percent Recovery
4.5	98.1 - 112.2
9.5	96.8 - 111.1
34.5	93.7 - 114.3

PRECISION OF GREAT LAKES INSTRUMENTS' TURBIDITY METHOD

The range of the standard deviations and percent relative standard deviations (or percent coefficient of variations) associated with the triplicate observations of the total theoretical concentration of 10 fortified drinking water samples by the Great Lakes Instruments Turbidity Method were as follows:

Total Theoretical Turbidity (NTU)	Standard Deviation (NTU)	Relative Standard Deviation (%)
0.5	0.01 - 0.06	1.1 - 10.7
5.0	0.00 - 0.10	0.0 - 2.0
10.0	0.00	0.0 - 5.6
35.0	0.00 - 0.58	0.0 - 1.8

- 9.3** Accuracy and precision should be checked on a routine basis to monitor the overall performance of the instrument. A series of reagent blanks and check standards should be run to validate the quality of sample data. These checks should occur at a frequency that is required for regulatory compliance.

10. Safety

- 10.1** Operators handling reagents should wear safety glasses, rubber gloves, and appropriate protective clothing. Consult the Materials Safety Data Sheets for additional safety information before working with reagents.

11. Quality Assurance

- 11.1** Each laboratory using this method in regulated environmental monitoring is required to operate a formal quality assurance/control program. The minimum initial requirements of this program consist of the demonstration of the laboratory's capability with this method. On a continuing basis, the laboratory should check its performance (accuracy and precision) by analyzing reagent blanks and check standards, fortified blanks, and/or fortified samples, preferably at a minimum frequency of 10% of the total samples analyzed by the method. The laboratory should maintain the performance records that define the quality of the data generated with the method.

12. Pollution Prevention

- 12.1** Solution samples should be used, collected and disposed of in accordance with all Federal, state and local regulations.

13. Waste Management

- 13.1** In case of spill or release: Dilute with water. Dispose of in accordance with all Federal, state, and local regulations.

Bibliography

1. Book of ASTM Standards, Part 31, "Water", Standard D1889-71, p. 223 (1976).
2. Methods for the Examination of Water and Wastewater, 14th Edition p. 132. Method 214A, (1975).
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4. Methods for the Examination of Water & Wastewater, 16th Edition p. 135. Method 214A.
5. Standard Methods for the Certification of Laboratories Analyzing Drinking Water: Criteria and Procedures, Quality Assurance, EPA/570/9-90/008, April, 1990.

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